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NOTES ON SASSAFRAS.

EDWARD W. BERRY.

(WITH PLATE XVIII AND FOUR TEXT FIGURES)

MONOTYPIC genera are always of more than ordinary interest, especially when they have a geological history. Our common *Sassafras* proves no exception to this statement. Ranging in size from a bush to a tree 125 feet high and with a trunk seven feet in diameter,¹ distributed from Massachusetts west to Iowa and Kansas, and from Ontario and Michigan south to Florida and Texas, ascending to 3500 feet above the sea level in Virginia, it is equally at home in the dry sandy soil of some of our roadsides or in rich woodlands. Belonging to a cosmopolitan tropical family of over 900 species, some of which were well known in the most ancient times, and many of which are of considerable economic and medicinal value (camphor, cinnamon, etc.), the common *Sassafras* was first described by Linnaeus as *Laurus Sassafras*,² in allusion to the common Spanish name. It is with the leaves that we are principally concerned, and it is interesting to note that all of our manuals speak of them as "entire or three-lobed,"³ or as "entire to three-lobed,"⁴ although in reality they are often four or five-lobed, not occasionally, but regularly so, some trees having all their leaves similarly four or five-lobed, while I have occasionally found specimens with six lobes. Most authors, lacking the time or material for verification, repeat previously published statements which are often misleading. Believing that there is no organ whose variations are not without significance, especially in view of the importance recently assigned to the statistics of variation, I have examined several hundred leaves of *Sassafras* of all ages, from trees of all sizes, and from all positions; from saplings, shoots from trunks, barren and flowering branches, etc. A discussion

¹ BRITTON, *Illus. Fl.* 2: 97. ² *Sp. Pl.* 371. 1753. ³ WOOD, *Classbook*, p. 620.

⁴ GRAY, *Manual*; CHAPMAN, *Southern Flora*; BRITTON, *Ill. Flora*.

of the variations, necessarily brief, is followed by an examination of the numerous fossil leaf-forms which have been referred to this genus, and their probable relations are pointed out.

SIMPLE LEAVES.⁵—Greatest length 190^{mm}, greatest width 107^{mm}; shape varying from lanceolate, through ovate lanceolate, to almost orbicular; tip truncate, rounded, or cuspidate; lateral margins ascending at an angle of about 45° at their base; base narrow and more or less decurrent on the petiole, especially in young leaves; texture from membranaceous to coriaceous. In texture, however, as well as in general form and character of venation, the leaves of a single tree proclaim their relationship, so that particularly pointed lobes or the reverse, broad short leaves or the reverse, very thin or very thick leaves, whether simple, bilobed, trilobed, or multilobed, all have the same aspect.

Bud leaves are always narrow, with ascending laterals forming an angle of 30° or less; somewhat older leaves, about June 1, when they are about 60 or 70^{mm} in length, had the primaries and secondaries indistinguishable in 68 per cent. of the leaves examined, in numerous older leaves the primaries are only to be distinguished by their greater length, are rarely opposite, and sometimes have a pair of secondaries below them nearly as large. There were an equal number of primaries and secondaries on each side in 60 per cent. of the leaves examined.

BILOBED LEAVES.—The bilobed leaves are more variable than the simple leaves, varying in outline from oblong-lanceolate to nearly orbicular. The lateral lobe may be broadly rounded or even reduced to a small blunt protuberance, or it may be narrowly acute, extending at almost right angles, or directed upward and not extending above the basal half of the leaf; or it may extend as far as the tip of the main blade and nearly equal it in size. The sinus varies from a slight wide depression extending only one-eighth of the distance to the midrib, to one extending three-fourths of the distance, and wide and obtuse or narrow and acute. Venation, of course, is inequilateral. Eighty per cent. have first secondary lower, and primary generally higher on the lobed side.

⁵ It is well to note that any statements made here refer only to the series I have examined.

MULTILOBED LEAVES (*Plate XVIII.*)—It is among the 3-5-lobed leaves, however, that the greatest variation prevails. In the trilobed forms the lobes vary from broadly obtuse to narrowly acute (rarely retuse), from mere lateral prominences to broad lobes extending nearly to the top of the leaf. They

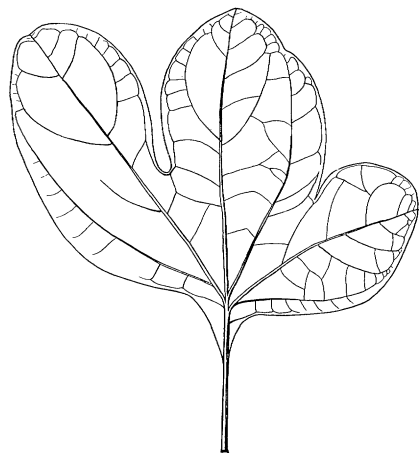


FIG. 1.—Abnormal leaf of *Sassafras*;
reduced two-thirds.

may never extend above the basal half of the leaf, although directed upward, or they may extend at right angles, or even occasionally be recurved. They may be orbicular or long narrow fingers enclosing a deep rounded sinus which extends nearly to the midrib. In a leaf 165^{mm} long and 127^{mm} wide the sinus extended to within 3.50^{mm} of the midrib. Out of 102 leaves considered of sufficient interest to sketch, 45 were approximately bilateral, and 57, or

about 56 per cent., were more or less greatly inequilateral. While this is not a natural proportion, as only divergent forms were preserved, it shows the wide range of variation from a leaf with one lobe acute and extending at right angles a distance of but 7^{mm} from the wide shallow sinus and three-elevenths from the base, the other oblong and ascending, extending nine-elevenths of the distance to the tip, and enclosing a deep, narrow sinus; to leaves in which one half is nearly the exact counterpart of the other. The base varies from narrowly ascending in the younger leaves to nearly truncate; all of the leaves seen, however, are more or less decurrent. The anomalous leaf shown in *fig. 1* is worthy of special mention as having an almost palmate venation, there being four and the indication of a fifth possible primary. The right hand sinus runs to a narrowly acute point, and entirely lacks the marginal venation so characteristic of *Sassafras*.

The bases of the primaries may be from 5-7^{mm} apart or they

may be opposite; they may form an acute angle with the midrib but 6 or 7^{mm} from its base; or they may not branch from the midrib until one-fourth the distance to the tip is traversed (one example four-fifths and one three-elevenths).

The typical five-lobed leaves, excluding those with four lobes, which are similar with the obliteration of the sinus of one of the lobes, or are the typical trilobed leaves with a small extra lobe on either side of the terminal or lateral lobes, sometimes even having six lobes (*fig. 4*), are strikingly handsome leaves and would hardly be taken for *Sassafras* leaves by even a trained observer. They undoubtedly represent a great development laterally of the typical trilobed forms with the additional small lobes (*fig. 2*), all the

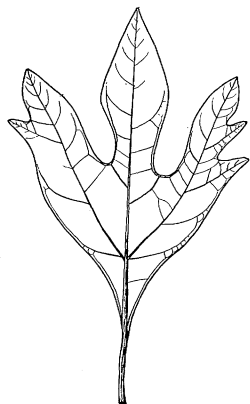


FIG. 2.—Abnormal leaf of *Sassafras*; reduced two-thirds.

lobes becoming greatly broadened and somewhat orbicular in outline. They are constant on some small trees which I have had under observation, and may represent the result of a superabundant food supply, as they all grew in rich soil of open woodlands. These leaves are nearly orbicular in outline, a

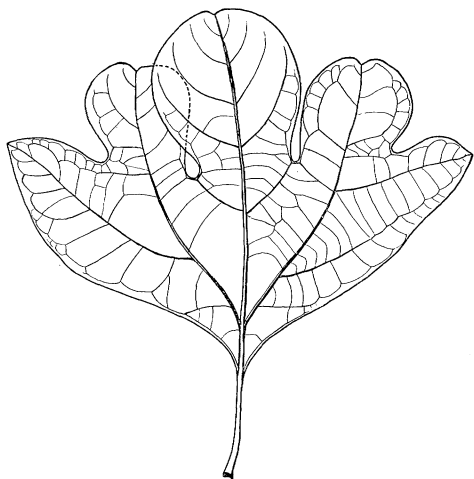


FIG. 3.—Abnormal leaf of *Sassafras*; reduced two-thirds.

large specimen measuring 156^{mm} in length by 200^{mm} in breadth (*fig. 3*), and consist of a central lobe and a pair of lateral lobes on each side, all nearly equal in size and separated by deep spatulate sinuses. The tips range from acute to rounded,

and in several instances are even retuse. The base of the leaf is in all cases decurrent and the angle of divergence of the ascending margins never exceeds and seldom equals 45° . While the comparative size of the lobes varies somewhat, the leaves are approximately bilaterally symmetrical. This form seems to have

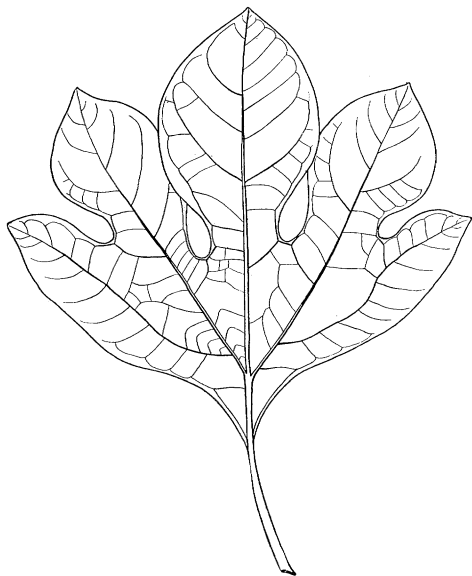


FIG. 4.—Abnormal leaf of *Sassafras*;
reduced two-thirds.

escaped attention heretofore, and none of the fossil forms referred to this genus resemble it in the least except *S. platanoides*. An ancient form which resembles these five-lobed leaves in outline is Fontaine's *Araliæphyllum obtusilobum*; the latter, however, has thicker veins and the lateral lobes are not so extensively developed; and the lateral which runs from the primary to the extra lobe is inserted much nearer the base than in the modern leaves.

The venation of the modern leaf is uniform in its variation. Safe rules for guidance in determining fossil forms would be the following: The primaries are opposite or sub-opposite (while this is not strictly applicable to the simple leaves it seems to be general in the lobed ones); they branch from the midrib a considerable distance above its base, thus differing from *Aralia*, *Cissites*, *Platanus*, etc.; the base is never enlarged to form basal lobes as it is in *Menispermities*, *Araliæphyllum*, *Protophyllum*, *Aspidiophyllum*, *Platanus basilobata*, etc; margins are entire; obviously, if any of the ancestral forms were dentate, this character would reappear occasionally in their descendants (all known *Lauraceae* have entire margins). A somewhat constant character in *Sassafras* leaves is the venation of the basal portion of

the blade. A pair of secondaries or tertiaries branches from the petiole at the juncture of the leaf-blade and forms its ascending margins, becoming slightly separated where the latter curves outward—a short distance above the base of the primary the lowest lateral curves toward the margin; just before reaching the margin it forks, the lower short branch joining the marginal vein and the other branch curving upward; the former together with the marginals form a rough inverted isosceles triangle, whose base is usually approximately on a level with the point of insertion of the primaries or slightly higher. This arrangement occurs in all the normal leaves examined by me, numbering several hundred, and in the abnormal forms it occurs in all but seven specimens out of 229. I fail to find this feature in any of the published figures of fossil forms, but it is a character which would be easily obliterated or overlooked, as marginal veins would not be distinguishable from margins unless they were of considerable size or the matrix were exceedingly fine-grained. A remarkable character of the modern lobed leaf, first pointed out by Lester F. Ward⁶, are the marginal veins at the bottom of the sinuses.

In the normal trilobed leaf about half the distance from the lateral primaries to the tip of the leaf is traversed before the first pair of secondaries branch from the midrib; the interval is filled with cross and horizontal veins which belong to the tertiary system; the secondaries in question leave the midrib at usually a wide angle, and curving upward pass directly to the sinuses. Here they are not lost but fork at a wide angle, often 160° , the two branches following the margins of the sinus for more or less distance until they leave them to join the branches given off from the primaries below and the next pair of secondaries above. This is nearly a constant feature of the modern leaf, recurring in substantially the same manner in all forms of the leaf, whether 2, 3, 4, 5, or 6-lobed. In leaves in which the sinuses approach the midrib closely there are numerous tertiary veins passing directly from the midrib to the sinus and from the primary to the sinus, joining its marginal vein. Just what purpose is served by this marginal vein in the economy of the leaf is difficult to

⁶Bull. 37, U. S. Geol. Survey, p. 61.

say. It might serve to strengthen the leaf and prevent tearing where the lobes are large; at any rate it is an acquired feature the origin of which is shown in some specimens and serves to prove that the ancestral leaf was simple, and not lobed as Ward holds; it also rules out the contention that ancient leaves lacking this arrangement are not forms of *Sassafras*, as we would hardly expect this character in the ancestral forms becoming lobed.

This marginal vein at the bottom of the sinus was lacking in fifteen single instances, and a secondary sinus lacked it in four instances out of a total of 201 leaves examined especially because of their diverse lobation. In nature it is undoubtedly a nearly constant character. In some cases the secondary which runs to the sinus is continued into the upper or the lateral lobe, and a tertiary from the midrib unites with one from the primary, then running to the sinus in the usual manner; or it may be a branch from the secondary together with one from the primary which forms the margin; the latter, however, is always thickened irrespective of the system to which it seems to belong. I have collected several specimens in which the secondary forks before reaching the sinus, the branches striding it after the manner which usually obtains in the lobed leaves of a variety of genera, the branches connecting with the branches from the next secondary above and with those from the primary below.

No fossil American *Sassafras* has, or at least shows, this peculiar marginal venation, but it occurs in a European representative of this genus according to Ward⁷. The secondary seems to run to the sinus in *S. bilobatum*, *S. platanoides*, and in some specimens of *S. progenitor*. The form which Lesquereux describes as *Aralia acerifolia*⁸ approximates this style of venation as does also the leaf referred to *Lindera venusta*⁹, which leaf Knowlton refers to Benzoin.

On general principles we would expect the ancestral *Sassafras* to have had simple, lanceolate, or ovate-lanceolate leaves with entire margins. Not only is this a rule among the Laura-

⁷ *Sassafras Ferretianum* Mass., from Senegal. Fl. Foss. de Seneg. *pl.* 12. *fig.* 1.

⁸ Cret. and Tert. Fl. *pl.* 49. *fig.* 5. ⁹ See Fl. Dak. Group, *pl.* 16. *figs.* 1-2.

ceae, but even in the existing *Sassafras*, aside from some striking exceptions, the majority of the leaves on full grown trees are simple. It is doubtful if we shall ever know these ancestral forms as such even if found, as they will probably be described as *Laurus*. In all probability the ancestral forms of all the dicotyledons were developed in an area remote from localities where fossilization was going on, as suggested by MacMillan¹⁰. In *Liriodendron* the variation from the oldest to the youngest leaf on a shoot from the modern form epitomizes the phylogeny in a general way. If the like holds good in *Sassafras* it would hint at an ancestor with trilobed leaves, for in all the forms which I have examined there seems to be a somewhat constant gradation from the outer (older) two or three-lobed leaves, through the simple lanceolate or ovate-lanceolate bud leaves, to the spatulate-ovate bud scales, which persist to form the involucre of the flower cluster.

Paleobotanists associate the name *Sassafras* with lobed leaves, and I do not know of a single specimen of a simple leaf which has been described as *Sassafras*, although several leaves referred to other species might easily be forms of *Sassafras*, as for instance *Cinnamomum Heeri* Lesq. from the Dakota group¹¹. Premising this much what shall we say of the relations of the numerous fossil species of bilobed and trilobed leaves which have been referred to this genus, ranging in time from the Potomac formation upward? While some are undoubted forms of *Sassafras* and have always been known as such, others are just as undoubtedly not forms of *Sassafras* at all. Very diverse opinions have been advanced as to their proper position. Saporta questions all of the references of trilobed leaves to *Sassafras*, and suggests their affinity with *Aralia*, pointing out their resemblance to the Central American genus *Oreopanax*. *Araliopsis* has always been a convenient shelf on which to place these leaves, but it seems to me that such references are altogether unsatisfactory. Lester F. Ward¹² is of the opinion that it is

¹⁰ The probable physiognomy of the Cretaceous plant population. *Amer. Nat.* 27: 336. 1893.

¹¹ Fl. Dak. Group, p. 105, *pl.* 15. *fig.* 1.

¹² *Proc. Nat. Museum* 11: 39-42. *pls.* 17-22. 1888.

doubtful if any of the so-called *Sassafras* leaves from the Dakota Group are correctly named, and says that they will eventually be recognized as interrelated with *Platanus*. While there is much in favor of this view, especially in the case of some species (which will be considered in their proper place), it is too sweeping and will have to be qualified.

The existing species is noted for its variable leaves, which may be simple, 2, 3, 4, 5, or 6-lobed, and we quote from Lesquereux to show with what certainty he regarded some of his determinations. In speaking of *S. platanooides*, he asks "is it referable to *Sassafras*, *Aralia*, or *Platanus* ?"¹³ *S. mirabile* he originally referred to *Platanus*; he asks "what is *Aspidiophyllum dentatum*, *Sassafras* or *Platanus* ?" He says of *S. dissectum* that it "has in the division of the lateral lobes the character of *Aralia*, while by its size and general outline it is a *Platanus*, and still further by the basilar prolongation and dentate lobes it is merely a variation of *S. mirabile*, or in the still farther development of the base it approximates *Aspidiophyllum* and *Menispermites*; in fact incomplete specimens of *Aspidiophyllum* which lack the basal portion have generally been referred to *Sassafras*."

I propose to consider the various fossil species in the light of the modern leaf, and believe that the relations which are suggested in the following pages, while necessarily imperfect, are more natural than any treatment heretofore accorded them. While all attempts at phylogeny are necessarily hypothetical, especially when dealing with only one set of organs, such as leaves, and many of these scattered and fragmentary, I have not hesitated to theorize, believing that such attempts when founded on careful study not only serve to coordinate existing knowledge of the group but furnish starting points for new lines of investigation. I exclude for the present any consideration of the species from Europe or the Arctic region.

The oldest species referred to this genus in America are Fontaine's three Potomac species as follows:

SASSAFRAS PARVIFOLIUM may be dismissed with the statement that there is nothing about this fragment of a small leaf to war-

¹³ Fl. Dak. Group. p. 231.

rant its reference to Sassafras. Of rare occurrence, it probably represents a young leaf of some unrelated species, or possibly of the leaf which Fontaine describes under the following name.

SASSAFRAS CRETACEUM HETEROLOBUM resembles *S. cretaceum obtusum* Lesq. from the Dakota formation and the Cheyenne sandstone, but is considerably smaller and with more pointed lateral lobes. We may class it with the doubtful forms referred to Cissites, its general outline (except the pointed lobes) being quite similar to *Cissites salisburiaefolius* Lesq. from the Dakota formation, which species Lesquereux determined as Populites, Sassafras, and Cissites successively. Or we may consider it as related to the ancestral form from which Platanus, so extensively developed in the succeeding strata, was developed. At any rate, I see no reason why it should be considered a species of Sassafras.

SASSAFRAS BILOBATUM.—While the outline of this leaf does not exactly conform to any modern bilobed Sassafras leaf known to me, it is nearer the latter than it is to any other leaf. The right-angled sinus with straight sides and running to a point is also a feature not seen in the modern leaf. In the latter, when the sinus runs to a point it is narrow and deep; and when it forms a right angle it is curved and the resulting lobe is generally obtuse and but slightly produced. We have characters which ally this ancient leaf to Sassafras in the decurrent base; the sub-opposite primaries, as they usually are in the bilobed leaves of the existing Sassafras; the position of the secondaries; and especially in the secondary running to the sinus, a feature we would hardly expect to find in so primitive a leaf. We would consider the bilobed leaf as a more ancient type than the trilobed form, and removed from the ancestral simple leaf by a series beginning with leaves with but a slight depression marking the position of the future sinus, and a slightly produced obtuse lobe, through forms partially paralleled in the modern leaf, in which these features were more and more emphasized. Just why the leaf became lobed is largely conjectural. The primaries form a more acute angle with the midrib than do the secondaries, especially in the simple leaves; they are the first and largest arteries branching from the midrib; in the growing leaf

they are carried upward, while new laterals are added toward the tip of the blade. It may be that the diagonal position of the leaves in the bud causes pressure at that particular lateral part near the tip of the primary, causing more or less atrophy of that part of the blade. This tendency once inaugurated the rest is simple, for those portions of the leaf at the tips of the primaries would have nearly all their leaf-forming energy expended in increasing the length of the lobe; possibly especially good environment was a factor in the original lobation, as witness the great development of the lateral portions of the leaf blade in the five-lobed forms occurring in rich soil. The Potomac species under discussion bears some resemblance to certain species referred to *Sterculia*, as well as to the asymmetrical terminal leaflets of some compound leaves, but I feel that we are justified in considering it a true *Sassafras*—the first that we can identify as such with any degree of certainty. As pointed out by Fontaine in the fragment of this leaf figured (by him), the opposite primary is considerably stouter than its fellow which runs to the lobe which is preserved, lending color to the supposition that this species was also trilobed.

The next forms which we have to consider are those recorded from the Cheyenne sandstone of Kansas. They were probably contemporaneous with the foregoing or possibly somewhat more recent, and flourished about 1000 miles to the westward.

SASSAFRAS sp. Knowlton in Hill, Am. Jour. Sci. 1: 212. 1895, represents fragmentary remains of doubtful identity from Belvidere, Kansas.

SASSAFRAS *OBTUSUM* Lesq., first described by him as *Populites salisburiaefolia* in 1868, then as *Sassafras*, and then as *Cissites*, and *SASSAFRAS* *CRETACEUM* *OBTUSUM* Lesq. had both better be referred to *Cissites*; at least this is a more natural place for them among the Lauraceae. Newberry includes them both in his composite species *S. cretaceum*. They resemble somewhat the trilobate forms of *Cissites harkerianus* Lesq., and also *C. insignis* Heer, and there is a distant resemblance to Dawson's *Sassafras Selwynii* from the Canadian Upper Laramie. They are both found in the Dakota formation, and *S. cretaceum obtusum*

also occurs in the sandstone at Belvidere, Kansas. The primaries are sub-basal, and the secondaries are straighter than in the modern *Sassafras*. The texture of these leaves differs widely, and the basal midrib is very wide. Some specimens show a tendency to become dentate. Hollick¹⁴ compares his *Cissites platanoidea* with *S. obtusum* Lesq.

SASSAFRAS MUDGEI Lesq.—According to Newberry, this is merely a variety of his *S. cretaceum*, but we fail to see any ground for this association except that they resemble somewhat the narrower lobed leaves ascribed to that species. They are somewhat intermediate between these forms and the more typical *S. acutilobum*, but are much more like the modern leaf than either. Lesquereux's *figs. 3 and 4. pl. 14*, Cret. Fl., we consider to be typical forms of this species. In the lengthening of the terminal lobe they approach the modern *Sassafras*; and we see no venation characters which are unlike the modern leaf, for while no marginal veins are discernible, they might have been present in *fig. 3*, and both figures approach *Sassafras* in the relations of their secondary members in this region. If it be certain that the fruit has been found in the same strata as Lesquereux asserts,¹⁵ it only serves to substantiate the impression otherwise obtained that they are true *Sassafras* leaves. The lateral margins of both the base and the lobes are straighter and more ascending than in the existing *Sassafras*, and the margin shows a tendency to become wavy. Lesquereux's other figure referred to this species differs in the size and direction of the lateral lobes, in the sub-basal primaries, and in the acute tip; the venation also is somewhat dissimilar, the ascending margins bulge outward, and the base is not decurrent on the petiole, as it is most markedly in his *figs. 3 and 4*. It resembles somewhat the forms which Newberry refers to *S. acutilobum*, but we do not consider it a *Sassafras*. Ward's fragmentary leaves from the Black Hills are of doubtful identity. The more perfect specimens which he originally referred to *Lindera venusta* Lesq., which it resembles in outline, is a smaller leaf than *S. Mudgei*, with sub-basal primaries, considerable breadth of blade, and

¹⁴Bull. Torr. Bot. Club 22: 226. 1895.

¹⁵Fl. Dak. Group, p. 230.

reduced terminal lobe. It may be Platanoid, Cissoid, or Aralioid, but is hardly a Sassafras leaf. If the reference of leaves from the Cheyenne sandstone to this species be correct, it had a considerable range in time, extending from the Lower into the Upper Cretaceous.

SASSAFRAS CRETACEUM RECURVATUM Newb.—Three to five-lobed subcoriaceous leaves; primaries branching from the midrib in the decurrent base, borders undulate; resembling the Araliaceae in the tendency to become five-lobed. Newberry's and Lesquereux's figures¹⁶ agree with each other and differ from those of *S. cretaceum*, of which Newberry considers them a variety in the craspedodrome venation, and the tendency of the lobes to become sub-lobate or undulatory, a tendency quite pronounced in Lesquereux's specimens cited. Lesquereux's third figure¹⁷ differs in being distinctly trilobate with camptodrome venation, and greatly resembles in outline the leaves which he refers to *S. cretaceum*. It also resembles his *S. mirabile*, being, however, fuller in its basal half. The typical forms of this species¹⁸ are closely related to some of the forms of *Platanus latior* and *P. Heerii* in the undulate margins and the strong development of the secondary branches from the midrib¹⁹ and undoubtedly should be referred to *Platanus*.

SASSAFRAS LECONTEANUM Lesq.—This name embraces leaves from the Dakota Group at Fort Harker, and remains doubtfully ascribed to Nanaimo, Vancouver island. Schimper²⁰ says of them, "Lauraceae, but doubtful Sassafras." Lesquereux²¹ says their "relation is with the European Tertiary Benzoin, and the existing Nectandra and Lindera." While modern opinion places them in the genus *Persea*, I am disposed to follow Heer in considering them a species of *Magnolia*; they are certainly not *Sassafras*.

SASSAFRAS ACUTILOBUM Lesq.—The leaves from the Amboy

¹⁶ Cret. Fl. *pl.* 10. *figs.* 4-5. ¹⁷ Cret. Fl. *pl.* 10. *fig.* 3.

¹⁸ NEWBERRY, Later Ext. Fl. N. A., *pl.* 9, *fig.* 2, and Lesquereux, Cret. Fl. *pl.* 10. *figs.* 4-5.

¹⁹ Compare with Cret. Fl. *pl.* 7. *fig.* 2; *pl.* 8. *fig.* 4; *pl.* 9. *fig.* 1.

²⁰ Pal. Veg. 2: 836.

²¹ Cret. Fl. p. 75.

clays of New Jersey, which Newberry refers to *S. acutilobum*, as well as the single leaf described under this name by Hollick from Glen Cove, L. I., are quite different from the majority of Lesquereux's figured specimens from the Dakota formation, and evidently are not Sassafras leaves. Newberry's two small figures are fragments which resemble *Ficus Woolsoni* in the position and direction of their primaries, the less fragmentary specimens resemble somewhat those leaves which Newberry refers to *Cissites formosus*. They are broad leaves with more or less laterally directed, short, broad, acute lobes; the primaries are all basal except in one specimen which might be a fragment of Sassafras or almost any other triple-veined leaf; the secondaries branch from the midrib at irregular intervals and arch, forming laterally directed loops a considerable distance from the margin. Lesquereux's *S. acutilobum*, on the other hand, has long, narrowly pointed lobes, the primaries are not basal, the secondaries are numerous and branch from the midrib at regular intervals, and ascend in regular curves to join the one next above near the margin. His larger leaf greatly resembles the trilobed leaves which he refers to *Aralia Wellingtoniana* from the same formation.²² The form and size are the same, the primary venation is similar, the secondaries arch with almost the same regularity, and form similar ascending curves. In the *Aralia* leaves, however, the secondaries in the terminal portions are craspedodrome or straight, running to the dentate points of the margin, and the basal portion of the leaf is produced farther down the petiole. It is also very similar to some of Newberry's figures of *S. cretaceum*, and together with them probably represent transition forms between *S. cretaceum* and *Aralia* (so-called). Probable Sassafras fruit has been found in the same strata with *S. acutilobum*²³, tending to show that it is a true Sassafras, notwithstanding its dissimilarities; however, this is not certain, as the leaves and fruit were not found associated. Lesquereux's smallest figure of *S. acutilobum* is considerably smaller, with the lobes directed upward, and is probably a young leaf of his larger form. His other figure approaches some of the leaves which Newberry refers to this species, but has

²² See Fl. Dak. Group, *pl. 21, fig. 1.*²³ LESQUEREUX, Fl. Dak. Group, p. 230.

narrower and more produced lobes; the secondaries, while indistinct, seem to conform to those of Lesquereux's other specimens, thereby differing from Newberry's leaves. The two series are, furthermore, widely separated geographically and are from different geological horizons. As previously stated, the Amboy clay leaves show no affinity to *Sassafras*; especially is this so in the very small, probably young leaves. Whether the Dakota group forms are *Sassafras* or not is not easy to decide. No modern *Sassafras* leaves which I have seen have the primaries and the lateral lobes so nearly horizontal; the secondaries are not so uniformly regular, nor do they curve upward to join the next above at a point. In the modern leaf an outwardly and downwardly directed branch from the latter is emphasized. There is never such an open sinus, amounting as it does to nearly 90° , and the lobes in the modern leaf have their margins inflated and not straight. In these ancient leaves the sinus never has a marginal vein, the secondary in this region forking and striding it, or curving to join its neighbor. In all cases the secondary system seems to be uniform throughout the leaf, while in the modern leaf there is always evidence of changed conditions in that region around the sinus; the secondaries or their representatives from both the primaries and midrib are changed in size and direction and usually belong to the tertiary system. None of the Dakota leaves of this species show the characteristic basal venation of the modern leaf. While we should not, necessarily, expect Cretaceous species to conform to the modern type, still the character of the secondary system in the former is so different from what would obtain in a leaf descended from a simple ancestor, such as we hold *Sassafras* to have done, that we are inclined to associate these leaves with those trilobed forms which have been referred to *Aralia*, laying aside, for the present, any consideration as to whether or no they are true species of *Aralia*. Lesquereux originally considered his leaves to be a variety of *S. Mudgei*, which form they resemble somewhat distantly. Leaves which have been referred to this species (*S. acutilobum*) have been found in both the Lower and Upper Cretaceous, and at the following localities: Woodbridge and Cliffwood, N. J.; near Ft.

Harker and along the Salina river, Kansas; Glen Cove, Long Island, and at Martha's vineyard. Velenovsky identifies it in the Cenomanian of Bohemia, and Oswald Heer's Greenland specimen which he refers to *S. recurvata* probably belongs here (Fl. Foss. Arct. 6: pl. 39. fig. 4).

SASSAFRAS SUBINTEGRIFOLIUM Lesq.—This leaf Lesquereux refers²⁴ doubtfully to this species. He is positive that it is referable to some member of the Lauraceae, comparing the secondary venation to that of *S. Aesculapi* Heer, and the nearly round or polygonal reticulation to that of Benzoin. Later²⁵ he believed that it represents only a deformation of *S. cretaceum*, especially the var. *obtusum*. The bilobate form is included by Newberry in his *S. cretaceum*, and Lesquereux seems inclined to agree with this reference. Their two figures of bilobate leaves, however, are very dissimilar. The tertiary system and general outline are clearly like Sassafras, the secondaries are more ascending, causing the sinus to be midway between the primary and the first secondary, instead of the secondary running to it and becoming marginal as occurs in the majority of modern leaves; the primary to the entire side is straighter; the lateral branches of the primaries are longer and straighter than in the modern leaf; the pair of secondaries below the primaries is also a character not found in modern leaves, where the lowest lateral branches from the primaries and joins the marginal veins to form an inverted triangle. Passing over the ambiguous form whose positive relations are obscure, we would say in regard to the bilobate form that, while it lacks the basal nervation and the secondary to the sinus of the modern leaf, it is similar in outline, in primary and tertiary venation, and more nearly resembles Sassafras than any other leaf-form. We would therefore retain it in this genus, keeping it separate from the *S. cretaceum* of Newberry.

The Laramie species comprise three or four forms. The first, SASSAFRAS sp. Lesq., from six miles above Spring cañon, Montana, is not afterward mentioned by that author, and as it was never figured we can dismiss it as an undeterminable fragment. We mention also Dawson's SASSAFRAS sp., from the

²⁴ Cret. Fl. pl. 3. fig. 5.

²⁵ Cret. and Tert. Fl.

Upper Cretaceous of Baynes sound, Vancouver island. All are imperfect specimens, representing a small apparently trilobed leaf of doubtful affinities.

SASSAFRAS SELWYNII Dawson.—Dawson says of this leaf “As much entitled to be referred to *Sassafras* as many of the Cretaceous species; near to *S. cretaceum* Newberry, particularly the variety *obtusum* Lesq.” From the Upper Laramie of the Souris river region; it was the first representative of this genus in the Laramie. It resembles *Aralia acerifolia* and *A. notata* Lesq., especially the latter, in its venation. The rounded base and basal primaries preclude us from considering it a species of *Sassafras*.

SASSAFRAS (ARALIOPSIS) BURPEANA Dawson.—From the Canadian Upper Laramie at Shagnappi point, Calgary, Canada. This species can also hardly be considered a *Sassafras*. The secondaries are regularly spaced and straight, the margins of the terminal and one lateral lobe are straight. It may represent the terminal portion of a compound leaf, such as *Rhus* or *Sapindus*²⁶ or it may be the fragment of an *Aralia* leaf (see *A. Masoni* Lesq). Lester F. Ward considers²⁷ both *S. Burpeana* and *S. Selwynii* as belonging to the Platanoid group of leaves. Neither form can be allied to any modern *Sassafras* leaf by any characters they present, unless it be the fact that they are trilobed, as are also some forms of *Aralia*, *Cissites*, *Platanus*, *Aspidiophyllum*, *Menispermities*, etc. This leaves not a single species of this genus in the Laramie, although *Sassafras* must have been present in the flora of that period.

SASSAFRAS (ARALIOPSIS) HARKERIANUM Lesq.—Lesquereux says of this form, “evidently related to *S. cretaceum obtusum* and to *S. obtusum*,” and “evidently related to *Araliopsis*.” The name includes rounded, trilobate leaves; nearly simple rounded leaves; and simple acuminate leaves very similar to *Cissites acuminatus* Lesq. The primaries are sub-basal as in the latter, or are inserted some distance from the base of the blade as in *Cissites Heerii* Lesq. The trilobate forms are included by New-

²⁶ Compare with Lesq., Fl. Dak. Group, *pl.* 56. *fig.* 4; *pl.* 64. *fig.* 18.

²⁷ Geol. Dist. Fossil plants, p. 842.

berry in his *S. cretaceum*; his figure however differs from Lesquereux's in that the primaries are as in the modern Sassafras and not sub-basal, as in the leaf figured by Lesquereux. It is well to consider these leaves as belonging to the Cissoïd group. The veins, both primary and secondary, are straighter than in Sassafras, and more ascending, and are usually craspedodrome and not camptodrome as in Sassafras. All are found in Dakota strata.

SASSAFRAS PROGENITOR Newberry.—Newberry is very positive that this leaf is a true Sassafras, with which view we entirely agree. The small leaf is the exact counterpart of the modern Sassafras leaf in outline and venation, with the exception that the primaries are basal. While no marginal veins are visible at the sinuses, the first secondaries leave the midrib and curve upward, running directly to the sinuses as in the existing Sassafras leaves. Hollick's specimen from Long island, while fragmentary, has a short branch running to the sinus in the half of the leaf blade which is preserved. Newberry's other figures each lack the basal portion of the blade and one of the lateral lobes; the lobes are more obtuse than in his smaller specimen. While the sinus appears to lack a marginal vein, the disposition of the secondaries and tertiaries in this region is Sassafras-like. The species is thus far confined to the Potomac formation, extending from the Amboy clays to the Island series, and is remarkable in that a Lower Cretaceous form should resemble so closely the existing species.

SASSAFRAS DISSECTUM Lesq.—These very large, palmately five-lobed, coriaceous leaves from the Dakota formation of Kansas were hardly borne upon a Sassafras tree. They resemble somewhat *S. mirabile* and *Platanus primaeva*, and Lesquereux considers them²⁸ a possible link between these two genera. Later he compares them to *Aspidiophyllum trilobatum*, from which they differ in their entire lateral lobes; in the smooth and not rugose areolation; and in having a narrow decurrent, instead of an expanded base. Aside from the character of the

²⁸ Fl. Dak. Group, p. 101.

base, they also resemble Lesquereux's figure²⁹ of *Aspidiophyllum dentatum*, agreeing exactly except that in the latter the border is sometimes obtusely dentate.

SASSAFRAS DISSECTUM SYMMETRICUM Hollick.—What was said of *S. dissectum* applies equally well to this variety, at least in so far as its characters are known. The fact that the primaries are opposite is hardly a varietal character, as witness the variability in this respect among leaves of the existing *Sassafras*. The only other differential character, therefore, is that the leaf-blade is not decurrent on the petiole but ends at the insertion of the primaries. As the general shape of the base is like that of the species, and as the variety is founded on a single imperfect specimen, it would perhaps be well to consider it as identical with *S. dissectum*, at least until the discovery of more complete material. The specimen in question is from the Dakota formation near Fort Harker, Kansas.

SASSAFRAS CRETACEUM Newberry.—Newberry includes under this name the various forms described by Lesquereux as *S. Mudgei*, *S. subintegrifolium*, *S. integrifolium*, *S. obtusum*, *S. cretaceum dentatum*, *S. cretaceum obtusum*, *S. acutilobum*, *Cissites harkerianus*, and *C. salisburiaefolius*. While this shows the undoubted composite nature of *S. cretaceum*, it also shows that the extremes of leaf form above mentioned are so closely connected with the more typical leaf by a series of intermediate forms that the question of where one species shall end and another begin is an extremely difficult one. We consider the leaf figured on *pl. 6. fig. 1*, Later Ext. Fl., to be the typical form of this species. It bears considerable resemblance to some modern *Sassafras* leaves. A slight widening of the terminal lobe of some of these in the region of its base would give a leaf strikingly like *S. cretaceum*; or were the sinuses of the latter slightly deeper we would have the typical modern leaf. The basal portion of the leaf is like *Sassafras*, and the indications point to a similar venation in this region. The first pair of secondaries do not branch to form margins of the sinuses; the left one runs directly to the sinus, however, and may possibly have con-

²⁹ Fl. Dak. Group, *pl. 39. fig. 1*.

formed to the margin, but so small as to have been effaced in the specimen; the right one is stronger and runs almost to the sinus where it makes a sharp turn upward, continuing until it joins the next secondary. This feature is analogous to those in the modern leaf, which indicates the mode of origin of this peculiar character. This leaf seems to form a central figure from which a series of forms grade in several directions, culminating in quite dissimilar leaves. Lesquereux's *S. cretaceum* is a more Platanoid leaf, with more acute tips, a tendency to become dentate, and with the primaries inserted nearer the base. Closely allied to the preceding is his *S. (Araliopsis) mirabile*, which serves as a connecting link with his *Platanus recurvata*. From the aforementioned *S. cretaceum* of Lesquereux it is but a step to such a leaf as the one shown on *pl. 8. fig. 2*, Later Ext. Fl., and to the trilobed forms referred to *Cissites harkerianus*, and these in turn grade into the more Cissoid forms of this species, such as those shown on *pl. 11. fig. 3*, Cret. Fl. The primaries are basal and of not much greater caliber than the regularly succeeding straight secondaries. It is but a step from this leaf to that of *Cissites Heerii* on the one hand, with its palmately five-pointed blade; and to such forms of *Cissites acuminatus* as *pl. 5. fig. 4*, Cret. and Tert. Fl. on the other; which in turn, by the elimination of the decreasing dentate points, gives us the leaf figured at *3, pl. 5*, Cret. and Tert. Fl. In the second series of leaves diverging from the typical, *S. cretaceum*, *pl. 8. fig. 1*, Later Ext. Fl., is removed a slight distance by the shortening of the blade, the thickening of the primaries and secondaries, and the shortening and rounding of the lobes (*S. obtusum*); while a smaller leaf would be its logical descendant; and from these leaves to those referred to the typical *Cissites salisburiae-folius* is but a step. In the third series of leaves diverging from the typical *S. cretaceum*, we note that the leaf has its lobes much produced, narrow and running to a sharp point, as in the beautiful leaf on *pl. 7. fig. 1*, Later Ext. Fl., which however is still referred to *S. cretaceum*. Lesquereux's *S. acutilobum* does not differ from the preceding except in the direction of the lobes, which is scarcely a specific character. From this leaf it is no

great jump to those trilobed forms which are referred to *Aralia Wellingtoniana*, the chief difference being in the margin. Thus we have an interrelated series connecting those leaves which undoubtedly show affinity to *Sassafras* with those which are undoubtedly Platanoid on the one hand, and with others which are reasonably referred to *Cissites* and *Aralia* on the other.

SASSAFRAS MIRABILE Lesq.—Lesquereux says³⁰ of this leaf “its facies is like that of a *Platanus*, or of a group referable, perhaps, to the *Araliaceae*, like *Platanus nobilis* Newb., *P. jatropaefolia*, and *P. hercules* Unger, etc.” Its size, texture, obtusely dentate borders, and craspedodrome secondaries all stamp it as a *Platanus*, and we prefer to follow Newberry and consider it as variety of his *P. latiloba*. There is a distant resemblance to the trilobed forms of *Cissites harkerianus*, as well as to some forms which have been referred to *Sassafras cretaceum*; this however, is a much larger leaf than the latter, with sub-basal primaries.

SASSAFRAS (ARALIOPSIS) PAPILLOSUM Lesq.—Lesquereux writes of this leaf “though the general aspect of the fragment is like that of a leaf of *Platanus*, it has a more evident relation to *Sassafras (Araliopsis) mirabile* Lesq., from which it differs merely by the enlarged lateral lobes, the acutely dentate borders, and the papillose teeth; this has a marked degree of affinity to *Platanus primaeva* Lesq. and its varieties.” It is very similar to some of the leaves referred to *S. cretaceum*, especially the var. *grossedentatum* Lesq., and like the latter its more natural position is with the leaves of the Platanoid group, resembling as it does *P. latior*, *P. dissecta*, *P. latior grandidentata*, etc.

SASSAFRAS (ARALIOPSIS) PLATANOIDES Lesq.—It is not difficult to find analogues of this leaf in widely different genera. There are three forms from the Lower Potomac which it resembles: *Araliaephyllum acutilobum* Font., *Araliaephyllum aceroides* Font., and *Aceriphyllum aralioides* Font. Lesquereux³¹ considers it to be closely related to *Platanus Heerii*, but I fail to detect the resemblance in his published figures. Nearly all the five-lobed modern leaves of *Sassafras* resemble this species (*S. platanoides*)

³⁰ Cret. Fl. p. 81.

³¹ Cret. and Tert. Fl., p. 58.

in outline, the chief difference being that the main lateral sinuses are deeper in the modern leaf, thus giving the lobes somewhat orbicular outlines. The position of the primaries is similar; the branch from the primary to the extra lobes is similar; the secondaries are somewhat straighter in the ancient leaf. Although Lesquereux says "it is equally referable to *Sassafras* or to *Platanus*," we are disposed to consider the former as representing its more natural disposition, not only because of its similarity to the modern leaves just pointed out, but also in its narrowly produced base, and especially in the first secondary running direct to the sinus, as it seems to do in Lesquereux's figure; for although a small portion of this part of the leaf is missing, it is so nearly complete on the one side as to leave no alternative ending for the secondary in question.

SASSAFRAS (?) PRIMORDIALE Lesq.—This fragment from the Dakota group is of doubtful value. Its only distinguishable characters, namely the basal lobe with the narrowly extended terminal lobe and the secondary in the region of the sinus widely forked, certainly do not warrant its association with *Sassafras*. Lesquereux notes its resemblance to *S. acutilobum* and *S. Mudgei*.

SASSAFRAS CRETACEUM GROSSEDENTATUM Lesq.—Lesquereux says of this form that it "differs in nothing from the normal form except by its large size, with its borders deeply dentate. It is evident that the sharply acute teeth constitute a variety indicated already by the short teeth sometimes seen in the normal forms of the species." In all the leaves referred to *S. cretaceum*, however, the base is decurrent on the petiole as in the modern *Sassafras* leaf. Furthermore, in all of Newberry's figures of the species, while the margins are sometimes slightly toothed, the secondaries remain camptodrome and do not enter the teeth, thus differing from the leaf under consideration as well as from Lesquereux's figures of *S. cretaceum*,³² in which the secondaries are craspedodrome; the base, however, is decurrent as in Newberry's figures and in the modern leaf. This form differs but slightly from *S. papillosum*, and also bears considerable resem-

³² Cret. Fl., pl. 11. figs. 1-2.

blance to some of Lesquereux's figures of *Platanus latior* and some of its varieties, as well as to other species of *Platanus*; and there is no doubt in my mind of its *Platanoid* affinities.

SASSAFRAS HASTATUM, Newb.—Trilobed, hastate leaves with conical lobes, the lateral ones directed horizontally except in two specimens which approach somewhat *S. progenitor* from the same formation, especially Newberry's *fig. 5, pl. 27*, Fl. Amboy Cl., which in all probability should be referred to that species. The rest of his figures show the normal form of *S. hastatum*, which differs widely from any leaves which can with any degree of certainty be referred to *Sassafras*; they resemble somewhat the fragments referred by Newberry to *S. acutilobum*. In these, although the lateral lobes are horizontal, they are not basal, and in consequence the primaries branch from the midrib at an angle of about 30° instead of nearly 90° , as in *S. hastatum*. They also resemble the Amboy clay leaves referred by Newberry to *Aralia groenlandica*; and they also have somewhat the appearance of *A. polymorpha*, but differ in outline. The secondary system is more or less obscured, the primaries are horizontal as are the lateral lobes; all the lobes are conical; and the base is not decurrent on the petiole. No discernible characters hint at any *Sassafras* affinities; and the outline is so far removed from what obtains in any forms of the modern leaf that we are inclined to discredit their reference to that genus.

Of the two remaining forms which have been referred to this genus, SASSAFRAS (ARALIOPSIS) sp. Lesq. from the Amboy clays of Burts creek, N. J., is of doubtful value; and SASSAFRAS (ARALIOPSIS) CRETACEUM DENTATUM Lesq., representing obscurely dentate leaves of somewhat doubtful affinity, which serve to connect his *S. cretaceum* with its variety *grossedentatum*, both of which varieties seem more nearly related to *Platanus* than to *Sassafras*.

The varying similarity and interrelation of the forms heretofore referred to *Sassafras*, *Aralia*, *Platanus*, *Aspidiophyllum*, *Cissites*, etc., clearly indicate that a change must soon be made in our conception of these genera; and this not only applies to *Sassafras*, but to the various forms referred to the other genera as well, including also *Grewiopsis*, *Menispermities*, *Credneria*, etc.

Ward suggested³³ that they be referred to a new genus to be designated *Protoplatanus*, or some similar name indicative of their ancestral character; but it seems to me that such a comprehensive genus would be an unwieldy composite no more satisfactory than the present state of affairs, for surely *Platanus* was not the only modern form with this style of a leaf that has Cretaceous ancestors. Other Spermatophytes are well represented in strata of corresponding age, and analogy leads us to see no reason why *Sassafras*, *Aralia*, *Cissus*, *Liquidambar*, etc., should not be present. We may reasonably expect that the more we know of this flora the more it will be found to resemble the existing flora of North America; in fact, the tendency of paleobotanists has always been to underestimate the age of the American Cretaceous. All, or the majority of the Spermatophytes originally had, in all probability, simple leaves; their origin was polyphyletic; and it is very possible that a like environment caused lobation which was thus more or less similar in all of these genera, although the species were quite different in other respects. At the present day a series of leaves of *Vitis*, *Ampelopsis*, *Viburnum*, *Acer*, *Platanus*, etc., could be obtained which would appear to be as closely interrelated as are some of the Cretaceous forms.

SUMMARY.

Of the twenty-eight American forms which have been referred to *Sassafras* the following disposition is made:

Retained in *Sassafras*: *S. bilobatum*, from the Potomac formation; *S. Mudgei*, from the Cheyenne and Dakota sandstones; *S. progenitor*, from the Raritan and Island series; *S. subintegrifolium*, *S. platanoides*, and *S. cretaceum* (in part), all from the Dakota formation.

Referred to *Aralia*: *Sassafras acutilobum*, doubtfully.

Referred to *Cissites*: *S. harkerianum*, *S. obtusum*, and *S. cretaceum obtusum*.

Referred to *Platanus* or *Protoplatanus*: *S. dissectum*, *S. dissectum symmetricum*, *S. mirabile*, *S. papillosum*, *S. cretaceum dentatum* and *grossedentatum*, and *S. recurvatum*.

³³Bull. 37, U. S. Geol. Surv.

Doubtful: *S. parvifolium*, *S. cretaceum heterolobum*, *S. sp.* Lesq. (from Montana), *S. sp.* Dawson (from Canada), *S. sp.* Knowlton (from Kansas), *S. sp.* Lesq. (from New Jersey), *S. Selwynii*, *S. Burpeana*, *S. Leconteanum*, *S. primordiale*, and *S. hastatum*.

PASSAIC, N. J.

EXPLANATION OF PLATE XVIII.—One-half contours of leaves of *Sassafras Sassafras*, showing variety of lobation; reduced three-fourths.



BERRY on SASSAFRAS